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(71) Applicant: MEMOREX CORPORATION
San Tomas at Central Expressway
Santa Clara California 95052(US)

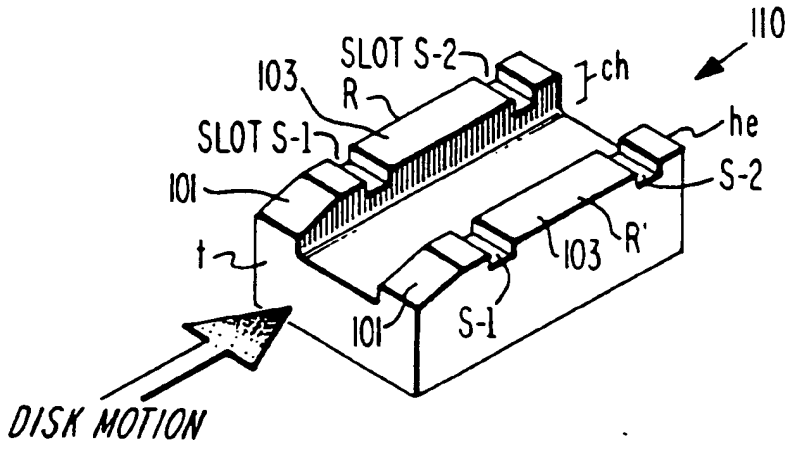
(72) Inventor: Ananth, Raju S.
6904 Windsor Way
San Jose California 95129(US)

(74) Representative: Kirby, Harold Douglas Benson et al
G.F. Redfern & Company Marlborough Lodge
14 Farncombe Road
Worthing West Sussex BN11 2BT(GB)

(54) Taper-flat slider.

(57) Embodiments include flying "catamaran" heads with air-bearing rail-faces which are "slotted" for burnishing enhancement.

FIG.7. MODIFIED 3680 SLIDER FOR BURNISHING.



EP 0 231 625 A1

MODIFIED TAPER-FLAT SLIDER AS BURNISHING HEAD

This invention relates to improved sliders as used in magnetic recording, and more particularly to a novel recording face configuration for recording on opposing sides of such disks.

BACKGROUND, FEATURES OF INVENTION

Magnetic recording systems using transducer heads that fly on an air-bearing film above magnetic recording media are well known in the art. Workers have developed and are continuing to develop such heads --for instance, enabling them to fly at a head spacing, between the transducer gap and the recording medium surface that is smaller and smaller --today, quite commonly reduced to as little as a few microinches. Such minuscule head spacing obviously complicates other problems, such as head stability.

Purpose:

One purpose hereof is to teach the design of a simple burnishing slider essentially by modifying a slider that would otherwise be used as a data head on the rigid disk to read and write.

Presently, workers used special heads that are designed to fly at the desired flying heights above the disk for "burnishing" purposes. "Burnishing" an oxide disk is intended to remove small asperities, such as iron oxide particles and resin-binder materials, so that the data head will not encounter such "material peaks" and be destabilized, damaged, etc.

Conventionally, the overall concept of a burnishing head design is quite different from the design of the actual head that is used to write and read data from the disk. The popular data heads are derived from what is gnerally known as "taper-flat" sliders that have two or more flat air bearing pads and front ramps on all the pads for flying stability.

A "crown head" design is used as burnishing head in a present-day drive. This has crowned air bearing pads (convex to the disk) and high preload (- 350 gm), and is one of the popular burnishing sliders. The air bearing characteristics of this "crowned" burnishing slider are such that the head is unstable especially when it is being loaded/unloaded onto/from the disk. There are other burnishing head designs, for example one that uses heads requiring special manufacturing steps - (cf. "Disk Burnishing Head Design for High Performance Disk Files", K.H. Elser and H.G. Wang, IBM Tech. Disclosure Bulletin, Vol. 26, November 1983).

Some workers have believed that the instability of flat pivoted sliders would be cured somewhat using a convex slider face (e.g., see IBM Journal July 1959 pp. 260 et seq.). However, no limits were ever appreciated (e.g., whether cylindrical or spherical; if spherical-convex, what radius limit); nor was any relation ever appreciated between spherical type faces and an "entry-taper", especially with respect to flexible media like floppy disks. This invention involves using a Taper-Flat (TF) slider - (magnetic recording head) for "burnishing". Workers are well aware of such TF sliders, having a "catamaran" recording face with rail faces characterized here as "tapered-flat" (TF) air bearings. This TF configuration will be seen to eliminate instabilities associated with conventional "flat" catamaran faces, as well as producing other advantageous features and characteristics.

Workers are familiar with the "flat air-bearing" - (FIG. 1) and the "taper-flat" air bearing (FIG. 2) configurations of the (catamaran rails of) conventionally known recording face configurations for non-contact recording on disk media. FIGS. 1 and 2 indicate these rather schematically. Also a "taper-flat" configuration is indicated, for example, in U.S. Patent No. 3,823,416 to Warner, issued July 9, 1974. This patent shows a magnetic head assembly apparently adapted for use with rigid magnetic disks, being thrust into contact therewith at times and flown over the disks at times. In this patent, a magnetic slider body is shown including three spaced "rails" with the bottom surfaces of the two outboard rails forming a "taper-flat" air-bearing surface. A magnetic core is longitudinally aligned with the center rail so as to define the transducing gap, this gap located at the "roll axis" so as to maintain the gap at substantially constant spacing from the record surface, even during rolling motions of the assembly. Such "catamaran" structures are typically adopted to "bring one closer to the media". While they have found considerable success with rigid media, a "taper-flat" catamaran has not been used to burnish. This invention is particularly adapted to providing such "taper-flat" air-bearing surfaces with a relatively flat (very large radius) spherical (or cylindrical) surface particularly adapted for burnishing.

The proposed burnishing head design essentially starts from a "taper-flat" design and incorporates one or more "burnishing-slots" at appropriate locations on the air bearing surfaces. In one

such embodiment (FIG. 7) two slot, one near the front ramp and the other near the trailing edge, of desired sizes (~ .010" wide and 0.005"-0.010" deep), have been made so that the air bearing pressure at these slots will be relieved to the atmospheric pressure, and burnishing enhanced.

The present invention differs from these known slider recording face configurations in that it is characterized by a pair of catamaran rails which are not only tapered-flat --as is illustrated for the TF faces of the side rails of the embodiment 10 in FIGS. 3 and 5, but are "burnish-slotted". Such "tapered-flat" rail faces may be characterized by a relatively "large" radius (about 1000 inches), e.g., as opposed to the conventional "small" (e.g., 2-10 inch) radius for spherical (non-catamaran) heads familiar to workers in this art. Such a slotted TF face is new in the art, especially for burnishing.

Such a slotted "TF" air-bearing surface will be recognized as quite advantageous as compared with conventional burnishing means, and provide a more genuinely stable catamaran head burnish configuration for disk media.

This will be surprising to workers, especially in view of how workers expect such rail discontinuities to "upset flying" and how they expect that such slotting can cut into the media.

Also surprising, it is found that such a TF head can be made to "fly" above media at "moderate" burnishing speeds and still nicely burnish a record surface.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features and advantages of the present invention will be appreciated by workers as they become better understood through reference to the following detailed description of the presently preferred embodiments, which should be considered in conjunction with the accompanying drawings, wherein like reference symbols denote like elements:

FIG. 1, a lower perspective view, simplified, of a prior art recording head characterized by catamaran rails exhibiting a "flat" air-bearing surface;

FIG. 2, a similar view of a similar prior art head having rails with taper-flat air-bearing surfaces;

FIG. 3, a similar view of a like recording head having rails with a "taper-spherical-flat" surface;

FIG. 4, a simplified plan view of a prior art spherical recording head face;

FIG. 5, a side view of an embodiment like that in FIG. 3 indicating a TF rail surface confronting a passing disk segment;

FIG. 6, an illustration after the manner of FIG. 5 indicating TF rail faces, with the placement of the read/write element and positioning forces - schematically indicated.

FIG. 7 a perspective schematic view of a preferred "slotted burnishing" head;

FIG. 8 a schematic plan view of an associated "acoustic emission sensor set-up";

FIGS. 9A, 10A, 11A plot sensor output (viz. record smoothness) prior to burnishing as per this teaching, while FIGS. 9B, 10B, 11B respectively plot such output after burnishing per this teaching; and

FIG. 12 is a view after FIG. 7 of a modified head embodiment.

DESCRIPTION OF PREFERRED EMBODIMENT

FIG. 7 indicates a preferred embodiment of the invention, namely a "slotted taper-flat" catamaran recording head 110 understood as adapted for high speed magnetic recording disks. Such a head (or slider) is characterized by a pair of opposed catamaran rails R, R' each having a TF recording face. Thus, each rail face will be understood as including a flat, bevel segment 101 adjacent the toe edge t of the head 110. Bevel 101 will be seen as merging into a "flat" (medium-confronting) segment 103, extending from the bevel 101 at least midway along the remaining rail-length --and preferably to the heel edge of the head (one rail being indicated in FIG. 6 in side elevation, and shown in typical recording orientation relative to a disk segment FD, passing as indicated by the arrow). Other materials, dimensions, fabrication and operating characteristics of this, and other, embodiments will be understood as conventional as known to workers in the art.

The following exemplary dimensions, for this embodiment, may help in understanding the invention: head, overall length: 0.160"

, overall width: 0.125"

, thickness: 0.040"

each rail: .016" wide with separation channel about 0.016" deep

slot S-1 located 0.010" aft of ramp 101

slot S-2 located .010" forward of trailing-edge te

slots S-1, S-2 may be about .0.010" wide ' about 5-10 mils deep.

The head will, in general, be constructed of a hard ferroceramic material lapped "ultra-smooth" (i.e., less than 1 μ-in. AA roughness). Other hard, smooth wear-resistant materials may occur to workers.

More particularly, each rail will include a flat air bearing surface 103 about 0.145 inches long and a flat bevel 101 about 0.015 inches long and tapered at about 0.5 degrees (angle α , FIG. 5) with respect to the mid-point tangent T-T to the "flat" surface 103.

Preferably, this burnishing slider is flown over the medium-to-be-burnished at relatively high speed [i.e., rotate disk about 3600 rpm or more, burnish 4"-7" Radius band] --e.g., recording speeds.

The principal function of forward slot S-1 is to reduce pitch at such media speed (e.g., here about 50 μ-radians preferred), though it can also help cut, e.g., a very large asperity, preventing it from damaging contact with the rail ABS. In some instances, where pitch is already satisfactory (or other means are used to control it), S-1 could be dispensed with. In any case its size and location will usually be determined by the desired pitch.

The principal function of aft slot S-2 is to cut away asperities, etc. and its size and location should be determined accordingly. In some cases, where more cutting is desired, more cutting slots may be added (e.g., one or more just forward of S-2); however, this should not reduce the "lift" given by the rail ABS below an adequate level (e.g., risk of crash. Further cutting may also be secured by serrating the rails at the tail edge of the slider, or otherwise providing cutting means there. Such is indicated in FIG. 12 for slider 210 (like 110 except as otherwise indicated), where the lapped air bearing surfaces at the tail edges are serrated at se.

Results:

The performance of the "two-slot burnishing slider" 110 has been evaluated using the well known Acoustic Emission (AE) test performed on relevant disks before and after burnishing with this head. The AE test involves placing a miniature accelerometer on the arm that carries a typical data head - (e.g., see FIG. 8), and collecting data as the data head flies on the disk to be characterized and processing the data. The processed accelerometer data (viz record asperities) is plotted in volts as a function of disk radial position of the data head as in FIGS. 9, 10 and 11. By comparing the two plots - (namely plot i before, and plot ii after burnishing), the performance of the burnishing process can be evaluated. It is seen that in the "two-slot" design, the front slots S-1 modify the pitch of the slider as it flies so that the burnishing is more effective. The major cutting is done, it seems, by the rear slots - (S-2).

Advantages over old methods:

The slotted slider design is stable; such a head can be loaded or unloaded as the disk is rotating.

Desired burnishing flying heights can be achieved by simply providing the appropriate number of slots, and correctly locating them.

No special arrangement to remove burnished debris is necessary as the slots help to readily collect debris that may be periodically cleaned-off.

No extra tedious manufacturing steps are necessary to make such "slotted slider" heads as the slots can be easily machined-out on an already-made conventional slider.

And, ordinary recording sliders that have been rejected for reasons other than faulty air-bearing performance (e.g., with defective transducers, etc.) may be recovered by using this design and adapting them for burnishing (after "slotting").

Alternative embodiments:

Workers will recognize that the foregoing principles of the invention may be modified to produce alternative embodiments. For instance, it should be understood that three-rail sliders may be likewise slotted; also one may similarly "slot" sliders with "spherical-flat" rail faces (i.e., having a curvature-radius of 1000" or more). And, in certain cases it will be feasible to use such a slotted catamaran head for burnishing of other rigid media.

It will be understood that the preferred embodiments described herein are only exemplary, and that the invention is capable of many modifications and variations in construction, arrangement and use without departing from the spirit of the invention. For example, the means and methods disclosed herein are also applicable to other like forms of rigid media. Also, this invention is believed applicable for providing improved transducer media relation in other like forms of recording and/or reproducing systems, such as those in which data is recorded and reproduced electrostatically, optically, etc.

The above examples of possible variations of the present invention are merely illustrative. Accordingly, the present invention is to be considered as including all possible modifications and variations coming within the scope of the invention as defined by the appended claims.

Claims

I. A burnishing arrangement comprising recording means adapted to be overflown relative to prescribed media, the recording means comprising a number of air-bearing surface rail means adapted to be flown above said media but relatively close thereto, each rail air-bearing surface being char-

acterized by an identical elongate air-bearing-surface ABS, each surface comprising slot means, whereby burnishing is enhanced.

2. The combination as recited in claim 1, as part of a read/write head including at least two slider rails with one rail along each aerodynamic edge of the head, each rail ABS being characterized by one or more slots cut across its width.

3. The combination as recited in claim 2, wherein each said medium-confronting rail ABS is characterized by a flat beveled entry-taper portion abutted by a relatively "flat" portion downstream therefrom, with at least one cutting-slot adjacent each rail tail plus pitch-adjust means.

4. The combination as recited in claim 3, wherein the pitch-adjust means comprises a forward-slot just aft of the entry-taper portion, all slots being slotted identically to be a few mils wide and a few mils deep.

5. The combination as recited in claim 1, as part of an assembly for burnishing a magnetic recording surface of said media during relative movement between the assembly and this recording surface, such assembly comprising:
a magnetic slider body, including at least two elongate slider rails, each rail having an elongate record-confronting air-bearing surface; and
slot means disposed along each such air-bearing rail surface and adapted to be presented in intimate burnish-relation with said media.

6. The combination as recited in claim 5, wherein said record-confronting rail surfaces are substantially co-planar, and provide substantially the entire effective air-bearing surface for the slider-body; the slot means comprising a forward-slot for pitch-reduction and at least one aft slot for burnish-cutting.

7. The combination as recited in claim 1, wherein the surface means is provided as the media-confronting face of magnetic recording slider rails adapted to be flown, at high burnish-speeds, over a recording disk; the slot means comprising at least one cutting slot adjacent the tail of each rail.

8. The combination as recited in claim 7, as adapted for use with media traveling at recording velocity or greater, each rail including pitch-adjustment means.

9. The combination as recited in claim 7, wherein two or more slider rails are present, with the outer rails air-bearing surface including an entry-taper portion, and an adjacent relatively "flat" portion, this flat portion characterized by a forward slot for pitch adjustment and one or more cutting-slots adjacent each rail trailing edge.

10. The combination as recited in claim 9, wherein said forward-slot is located just aft of the entry-segment and the cutting-slots are located just forward of the trailing edge of each slider rail.

11. The combination as recited in claim 1, wherein each rail's ABS face is slotted for pitch adjustment and for burnish-cutting.

12. A method of burnishing magnetic recording surfaces comprising the steps of:
providing magnetic recording slider means adapted to be translated in flying relation with said surfaces, the recording means comprising a number of rail air-bearing surface means adapted to be flown above said surfaces relatively close thereto, this surface means being characterized by a plurality of identical elongate air-bearing surfaces ABS, each surface being characterized by transverse slot means adapted to enhance burnishing.

13. The method as recited in claim 12, wherein the ABS are part of a read/write head including at least two slider rails, and whereby the AB surfaces comprise the medium-confronting ABS faces of the rails, each rail AB surface being characterized by one or more burnishing slots adjacent its trailing edge.

14. The method as recited in claim 13, wherein each said medium-confronting rail AB surface is characterized by a flat beveled entry-taper portion abutted by a "flat" portion downstream therefrom, with a forward pitch-adjust slot and one or more aft cutting-slots;
the slider being translated relative its recording surface at relatively high recording-level velocity and the forward slot being dimensioned and disposed to maintain optimum burnish-pitch at this velocity.

15. The method as recited in claim 14, wherein said "flat" rail AB surfaces include a number of such slots, each slot a few mils wide and a few mils deep.

16. The method as recited in claim 12, wherein the slider means is part of an assembly for burnishing a magnetic recording surface, this assembly comprising:
a magnetic slider body, including at least two elongate slider rails, each rail having an elongate relatively-flat record-confronting air-bearing surface with slotting means disposed along each such air-bearing rail surfaces; and
presenting these rail-surfaces in intimate burnish-relation with such a record surface.

17. The method as recited in claim 16, wherein said record-confronting rail surfaces are made substantially co-planar to provide substantially the entire effective air-bearing surface for each said rail; and wherein the slot means is dimensioned and disposed to enhance burnishing; the recording surface being translated past the slider means at recording-velocity or greater.

18. The method as recited in claim 12, wherein the slotted air-bearing surface means are presented as the media confronting face of a magnetic recording head and are flown, at high speed, over the recording surface of a rigid disk.

19. The method as recited in claim 18, as adapted for use with media traveling at recording velocity or more with the slot means dimensioned and disposed for burnish-cutting and for pitch-adjustment.

20. The method as recited in claim 18, wherein said face is provided as two or more slider rails, each rail presenting the said air-bearing surface means and each rail made to include an entry-taper portion, plus an adjacent "flat" portion, this flat portion characterized by a pitch-adjust slot and a cutting-slot.

21. The method of claim 20, wherein the pitch-adjust slot is disposed on a forward portion of each rail ABS and one or more cutting slots are disposed adjacent each rail trailing edge.

22. The method as recited in claim 12, wherein each said working segment of a rail is configured into a large-radius configuration having a minimum radius of curvature of approximately 1000 inches, and includes at least one slot for burnish cutting plus pitch-adjust means.

FIG.1.
Prior Art

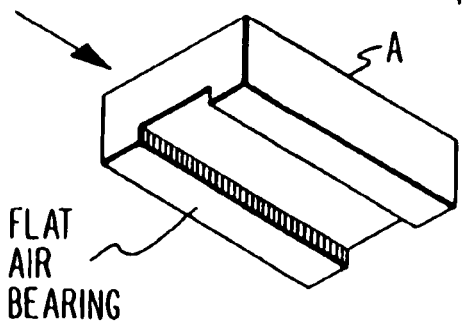


FIG.2.
Prior Art

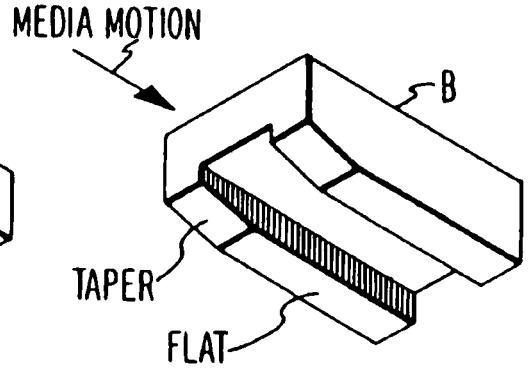


FIG.3.
("TSF")

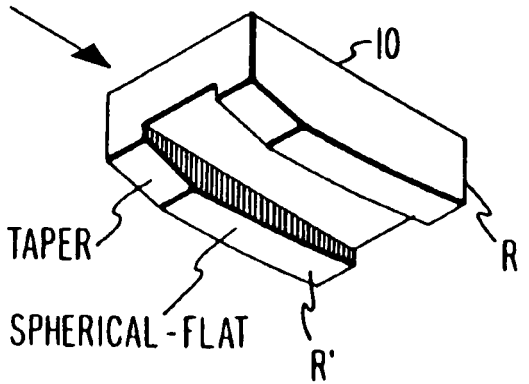


FIG.4.
Prior Art

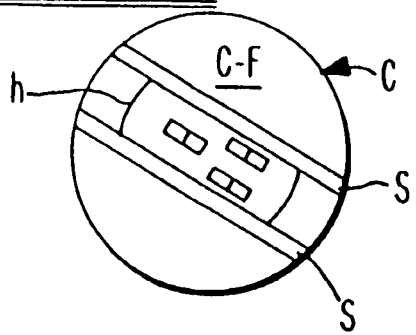


FIG.5.
("TSF")

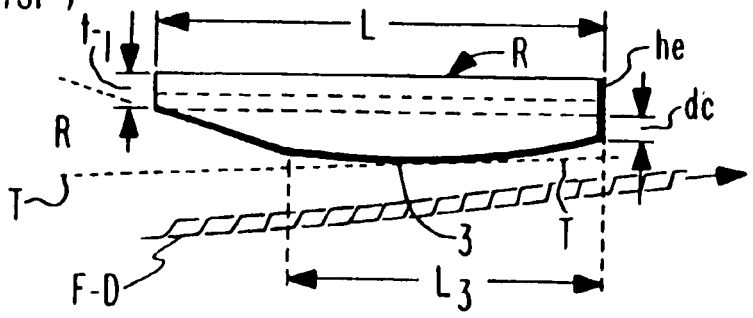


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FIG.6.

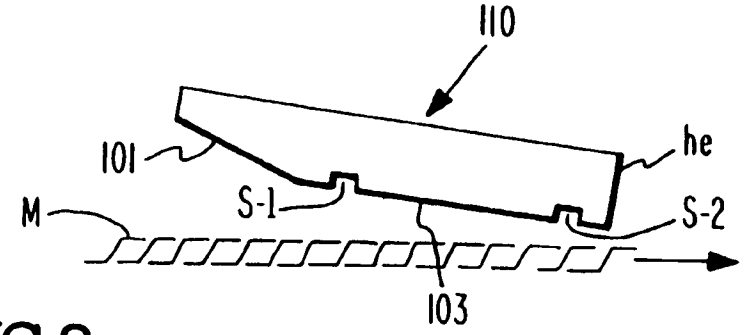

FIG.7. MODIFIED 3680 SLIDER FOR BURNISHING.

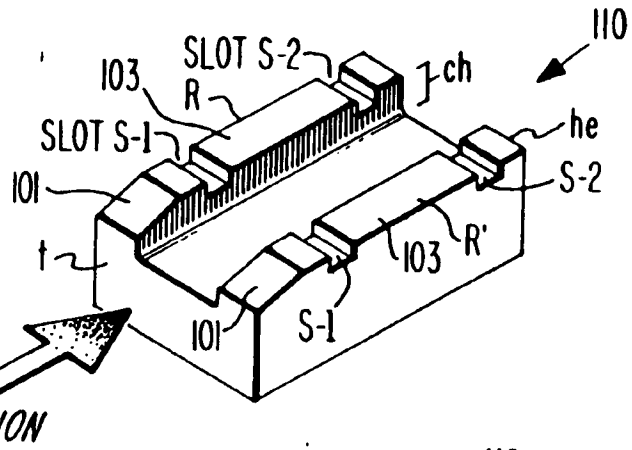

FIG.8.
ACOUSTIC EMISSION SENSOR SET-UP.

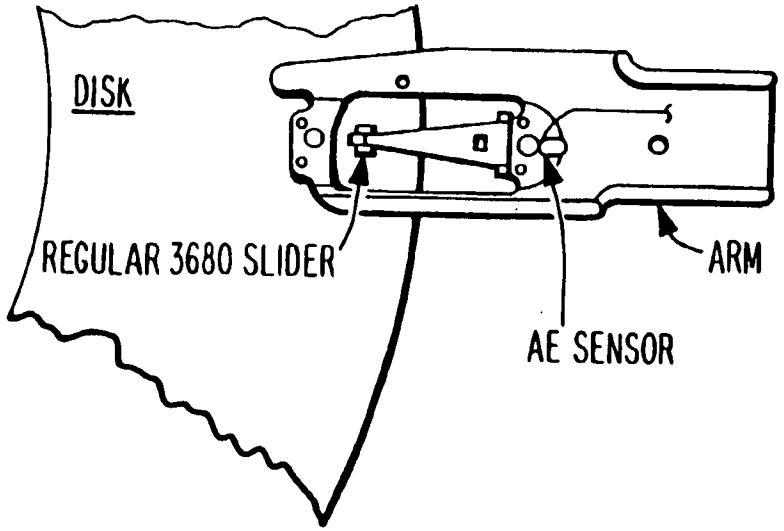

FIG.12.

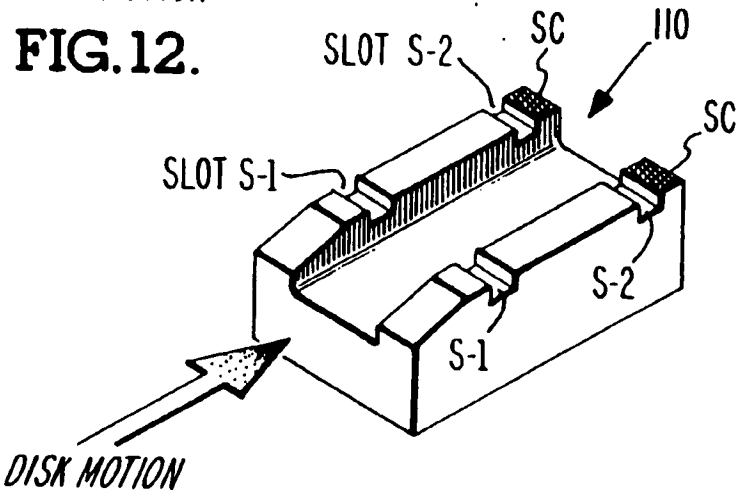

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FIG. 9A.

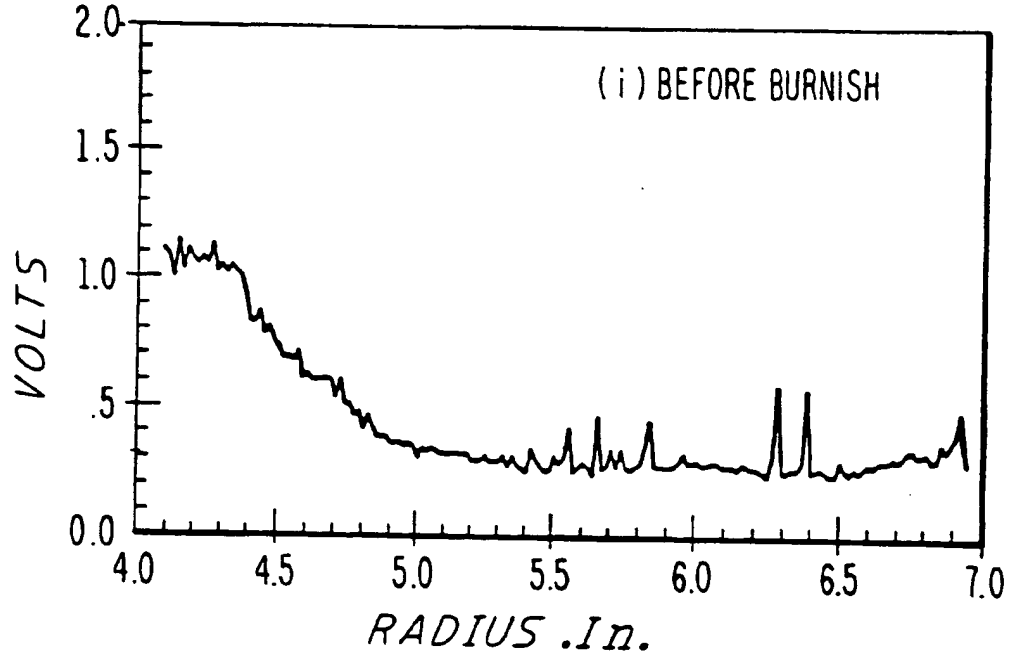

(i) BEFORE BURNISH
VOLTS
2.0
1.5
1.0
.5
0.0
4.0
4.5
5.0
5.5
6.0
6.5
7.0
RADIUS .In.

FIG. 9B.

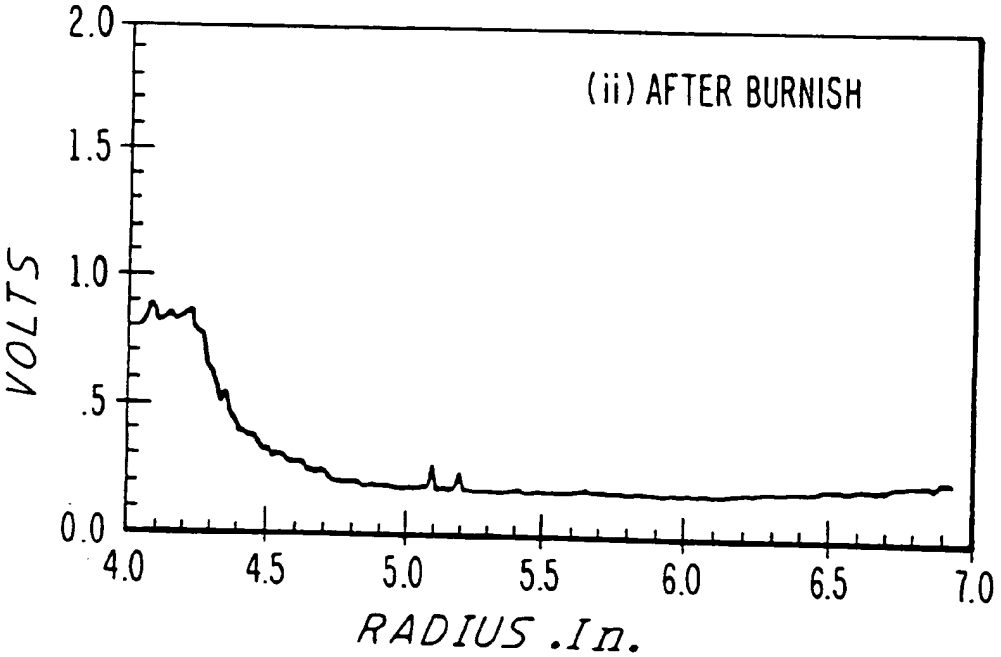

(ii) AFTER BURNISH
VOLTS
2.0
1.5
1.0
.5
0.0
4.0
4.5
5.0
5.5
6.0
6.5
7.0
RADIUS .In.

FIG.10B.

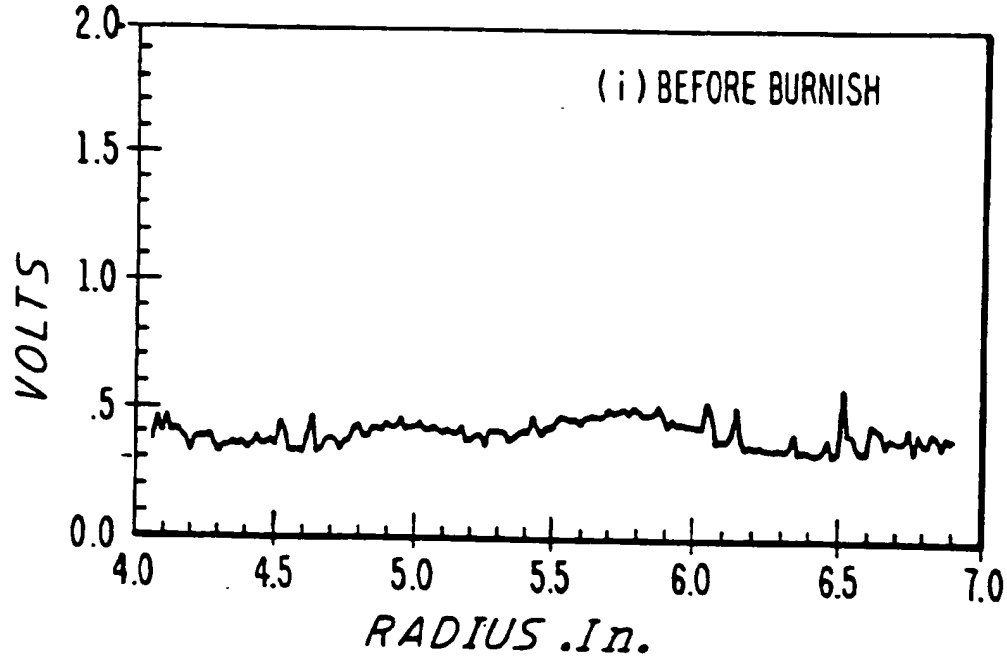


FIG.10A.

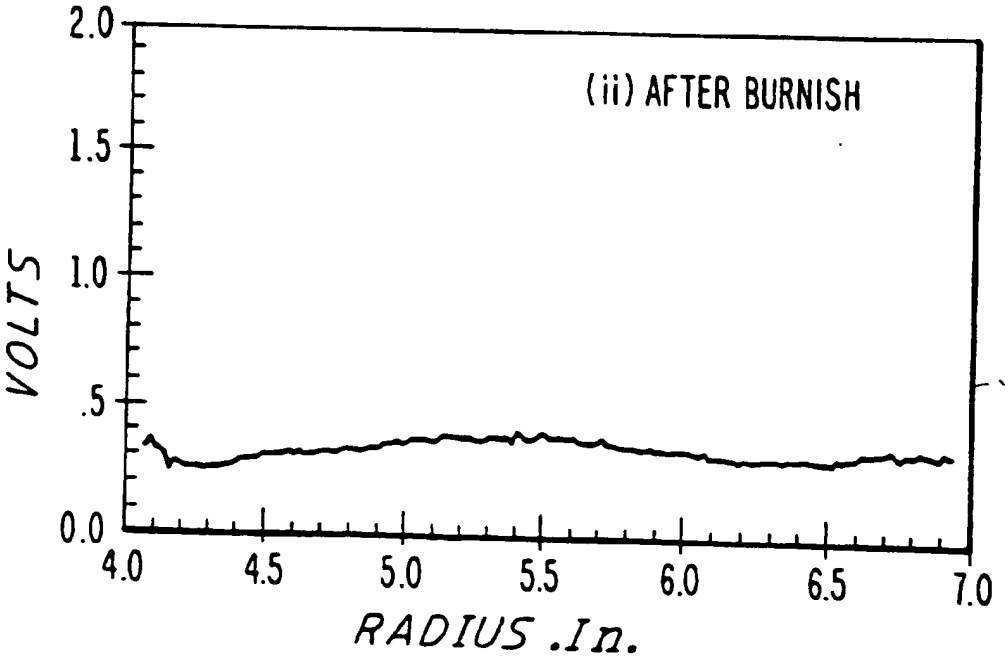


FIG.11A.

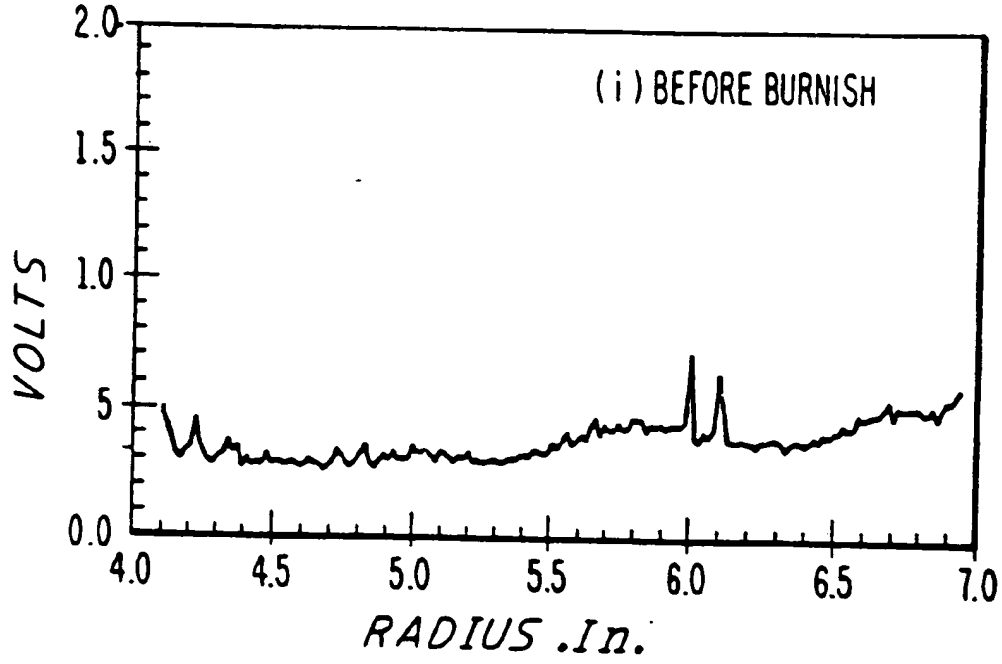
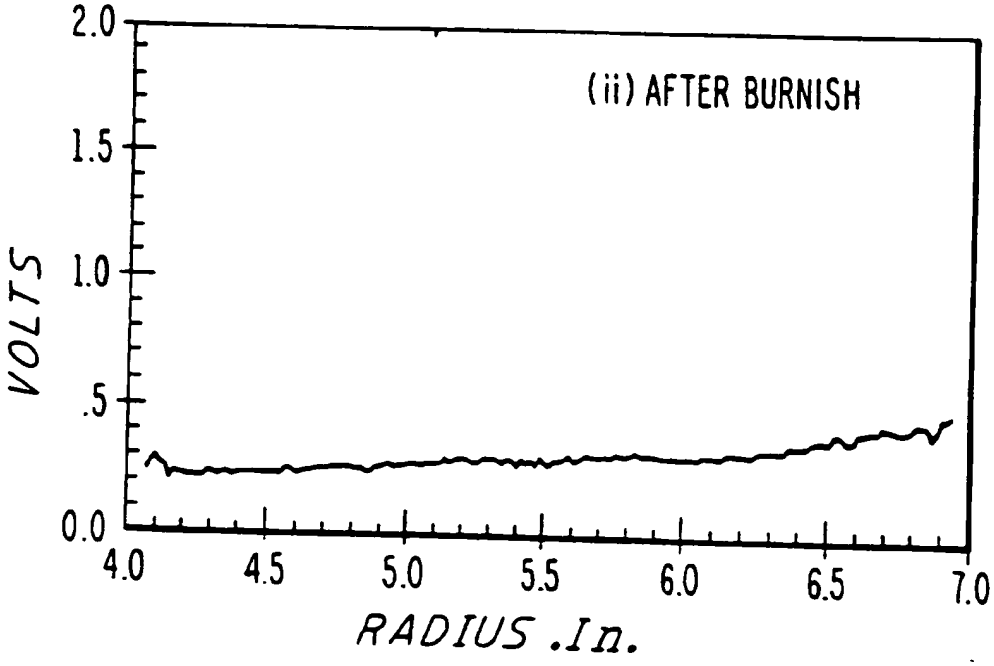


FIG.11B.



European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 86309717.6

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	EP - A1 - 0 107 411 (TOKYO SHIBAURA) * Fig. 9A,9B; abstract; page 8, lines 10-20 * --	1-22	G 11 B 5/60
X	US - A - 4 553 184 (OGISHIMA) * Fig. 2-6; column 3, line 59 - column 6, line 17 * --	1-22	
D,A	US - A - 3 823 416 (WARNER) * Fig. 1,2; abstract * ----	1-22	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

G 11 B 5/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	14-04-1987	BERGER

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons

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